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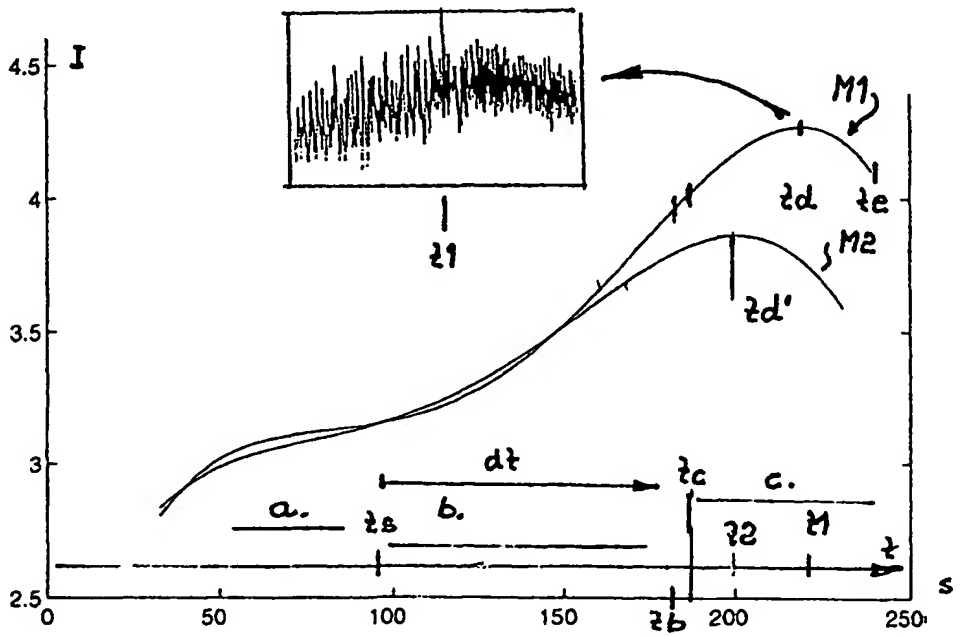

(57) Abstract

The present invention relates to a method and to a dough mixing arrangement with which a significant time point (-ts-) or several significant time points (-tb-) is/are used to stop the formation of dough at a critical time point (-tc-), where the following dough forming process, baking, etc., results in an end product that has good and uniform properties.

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TITLE OF INVENTION: A METHOD OF MIXING TOGETHER A NUMBER OF INGREDIENTS, AND A MIXER ARRANGEMENT

FIELD OF INVENTION

The present invention relates primarily to a method of mixing together a number of ingredients to form a dough mixture, such as flour, water and other ingredients included in a recipe that provides a pre-selected end product.

Although the concept of the invention encompasses all flour-containing and baked products, the invention will be described hereinafter by way of example solely with respect to one flour-containing product, such as bread.

The preparation of pasta and similar products is also included in the inventive concept.

It will be understood that expressions such as mixing flour, water and other ingredients, into a mixture, a dough mixture, do not refer solely to the use of one sort of flour, but also relate to mixtures of one or more sorts of flours such as to obtain desired end products.

The inventive method utilises a dough mixing arrangement whose construction can, in principle, include any known type of dough mixer.

The invention also enables the instantaneous rheological properties of the dough mixture to be evaluated either continuously or discontinuously during operation of a chosen mixer, including the stretch strength or toughness of the dough and the elasticity of the dough.

The present invention also relates to a dough mixing arrangement adapted for use in carrying out the inventive method to produce a dough mixture and including a chosen dough mixer and a mixer-adapted control unit, among other things.

The expression dough mixing arrangement shall include means which coact with said control unit or be connected to such means such as to enable time-wise variations in the rheological properties of the dough mixture to be evaluated during the dough mixing and dough forming process.

The dough mixer shall use a control unit, which may well be of a known kind and which functions to monitor and/or control the dough mixing process and which is supplemented with means and/or a computer programme that will operate in accordance with instructions given in accordance with the invention.

The present invention can be seen as a direct development of the method of mixing flour, water and other ingredients in a dough mixer, and a baking plant for utilizing said mixture illustrated and described in Swedish Patent Application 9703841-8 filed on October 22, 1997 (corresponding to the international patent application number PCT/SE98/01889).

BACKGROUND OF THE INVENTION

There are known in the art several different methods of mixing together flour and water and, as required by a specific recipe, a number of other ingredients so as to provide an ho-

mogenous mixture, and thereafter to work and develop the dough mixture for use in the production of a pre-selected end product in a dough mixer and in a baking process, in which such a dough mixture and dough mixer are included, such as to obtain an end product that has desired characteristics.

The earlier standpoint of techniques is described and illustrated in more detail in the aforementioned Swedish Patent Application.

It will also be noted that European Patent Publication EP-A1-0 428 241 teaches a method of producing a dough in a dough mixer in which the dough forming process is interrupted automatically when said process has reached a point in time and has proceeded over a period of time with which the structure of the dough is judged to be optimal.

The time point at which said optimal properties are considered to have been reached is determined by the energy consumption of the dough mixer in mixing the dough in relation to energy consumption measured in respect of a previously mixed reference dough.

The earlier publication also allows a dough forming process to be interrupted before the dough mixture exhibits a highest value (maximum rheological properties), and utilizes to this end a time declaration and a time limitation of the mixing process calculated from the time of starting the dough mixer.

In this case, formation of the dough is terminated when the electrical energy used to drive the mixer reaches a selected value applicable to the type of ingredients involved and depending on the weight of the dough mixture.

It will be noted that this known technique is unable to take into consideration different parameter variations, such as

variations in the dough and/or the quality of the flour used, temperature, mixer speeds, chosen ingredients, weather conditions, etc., or can only take such parameters into consideration to a very limited extent, when requiring a comparison to be made with an earlier produced reference mixture.

More particularly, this earlier publication teaches that the dough forming or dough mixing process shall be stopped when a predetermined level of energy consumption is reached.

It also teaches the possibility of allowing the dough mixer to work within different speed phases during the dough forming process.

Patent Publication US-A 5,472,273 teaches a computer controlled dough forming process.

A dough mixing arrangement may comprise a dough mixer, an electric motor, rotatable dough mixing devices, in the form of one or more spiral-shaped devices, wing-like devices or the like, and a control-unit associated means for evaluating instantaneous current and voltage values with respect to the motor input energy.

The current and voltage values concerned in this respect are related to the magnitude of the load and not to the fundamental signal configuration, and to a reference procedure without taking into account the influence of the temperature and the environmental influence on chosen ingredients.

With regard to features associated with the present invention, it can be mentioned that various methods of subjecting varying alternating voltages and alternating currents to signal processing procedures, both statistically and mathematically, are known to the art.

Although the principle on which the invention is based can be carried out by means of any appropriate signal processing theorem, the invention will be described and illustrated in the following description with reference to signal processing according to the varians theorem, by way of example.

Reference is made in this regard to the Handbook of Intelligent Sensors for Industrial Automation by Nello Zuech; Addison-Wesley Publishing Company, Inc., USA, Chapter 16, under the heading Sensor Fusion by David A. Dornfield, p. 419, and in particular pp. 438-441.

It is also known that in view of the fact that the qualitative properties of such ingredients (such as flour) can vary depending on storage time, moisture content, temperature, etc. it is difficult to create conditions which will nevertheless enable a desired end product, such as baked bread, to have a quality which conforms to predetermined criteria.

SUMMARY OF THE INVENTION

TECHNICAL PROBLEMS

When taking into consideration the technical deliberations that a person skilled in this particular art must make in order to provide a solution to one or more technical problems that he/she encounters, it will be seen that on the one hand it is necessary initially to realize the measures and/or the sequence of measures that must be undertaken to this end, and on the other hand to realize which means is/are required in solving one or more said problems. On this basis, it will be evident that the technical problems listed below are highly relevant to the development of the present invention.

When considering the present state of the art, as described above, it will be seen that because the structure of the

dough at the end of a dough forming process or dough forming method is of decisive significance to the end product, a technical problem resides in providing conditions that will enable the quality of the end product to be improved and ensured in accordance with preset requirements with respect to optimal properties, whilst lowering the energy requirement of the dough mixer used.

Another technical problem is one of providing a dough mixing process which, to a higher degree than earlier proposed processes, can terminate the dough mixing process more accurately at a chosen critical time point prior to the dough mixture exhibiting maximum rheological properties.

A technical problem also resides in the ability to evaluate this critical time point with the aid of simple means, and therewith halt the dough forming process when dough has been formed in the dough mixer at least over a chosen time period and exhibits predetermined rheological properties that are significant to the following baking process.

Another technical problem resides in creating conditions in which the mixing process carried out in the mixing arrangement to a selected critical time point will be less influenced by temperature and flour and will be less dependent on surrounding conditions and the choice of ingredients, as distinct from earlier known processes.

It will also be seen that in respect of dough mixing and in respect of terminating the mixing process at said selected critical time point, a further technical problem resides in realising the advantages afforded by evaluating the rheological properties of the dough either continuously or within significant time periods, and therewith sensing/detecting one or more time points in which the rheological properties have been seen to change significantly.

Another technical problem is one of realising the significance of and the advantages afforded by utilizing as one or more reference time points one or more time points at which chosen significant changes occur, and to commence from one such chosen reference time point an adapted timing process for the continued dough forming process up to the critical time point.

Another technical problem resides in the ability to find and/or create conditions in which a chosen reference time point will be situated close to the critical time point, or in which one of a number of chosen reference time points will be situated close to and time wise before or after said critical time point.

Yet another technical problem is one of realising the significance of and the advantages associated with the ability to correct an obtained reference time point with respect to different conditions, so as to enable an improved and qualitatively more uniform end product to be obtained by means of a chosen correction factor.

Another technical problem resides in realising that a simple solution to the aforesaid technical problems resides in enabling the reference time point to be established simply and effectively, for instance when an initial mixing process exhibits a first significant change in the rheological properties of the mixture.

Another technical problem is one of realising the significance and the advantages associated with the ability of selecting a predetermined dough mixer operating time on the basis of one such selected reference time point (i.e. not the time point at which the mixer was started), with the subse-

quent dough forming process being effected totally within a chosen dough forming structure.

Another technical problem is one of realising the significance and the advantages of terminating this predetermined time period slightly prior to a chosen critical time point, namely the time point at which the dough forming process is terminated.

Still another technical problem is one of realising the significance and the advantages of terminating the dough forming process at said critical time point or just before said time point, at the instance when significant changes in the rheological properties of the dough occur.

It will be seen that a technical problem is one of realising the significance and the advantages of selecting said critical time point at a chosen time period subsequent to evaluation of a chosen significant change in said rheological properties.

Another technical problem is one of realising the significance and the advantages of selecting the value of said predetermined time period empirically.

Yet another technical problem is one of realising the significance of continuing correction of the occurrence of said critical time point in accordance with a chosen second reference time point, dependent on different conditions, such as conditions caused by the subsequent working of the dough, the structure of the plant, the recipe, etc.

Another technical problem is one of realising the significance and the advantages of evaluating and establishing said critical time point and also of determining requisite correc-

tion factors when the rheological properties of the dough change significantly.

An additional technical problem is one of realising the significance of selecting a first reference time point (possibly corrected) on the occasion of a chosen first change in the dough structure and/or selecting a second reference time point (possibly corrected) on the occasion of a chosen second change in said dough structure, and so on, and of selecting said critical time point (possibly corrected) at a selected suitable dough structure for the following treatment of the dough up to the point at which a finished end product having chosen properties is obtained.

Another technical problem is one of realising the significant simpleness in referring said critical time point solely to those significant changes in the rheological properties of the dough that occur when the dough exhibits the second dough structure change, and to allow the critical time point to be readily evaluated via, *inter alia*, mathematical, statistical signal processing of that part of the variation of the current curve that relates to the variation in load on the dough mixer.

Another technical problem is one of realising the advantages associated with selecting the first reference time point at that instance when a pure ingredients mixture transforms into a polymerising and initial dough formation, and in using this time point as a reference time point during the whole of the dough mixing process.

Another technical problem is one of realising the significance of and the advantages associated with solely evaluating the critical time point in the case of certain applications, by following the course of the current curve and evaluating the critical time point directly from said curve, either when

the dough exhibits said second significantly changed rheological properties or an adapted time period thereafter.

Yet another technical problem is one of realising the significance and the advantages of evaluating the time-wise variation of the current curve in a signal processing aspect, and dividing this time-wise variation into sections of short duration during which the current values that occur are subjected to mathematical signal processing.

Another technical problem is one of realising the significance of carrying out said mathematical signal processing in accordance with one of a number of available theorems, such as the varians theorem.

Yet another technical problem is one of realising the significance and the advantages of giving a first sub-section of said time-wise variation chosen for signal processing purposes a time duration such that said sub-section will be overlapped by a following sub-section chosen for signal processing purposes.

Another technical problem is one of creating with the aid of simple means a dough mixing arrangement which is connected to a following baking plant and which is controlled by a control unit and with which the aforesaid technical problems can be readily solved, primarily via computer control of the dough mixture in the dough mixer.

It will also be seen that a technical problem is one of being able to insert different correction factors for the evaluated time points used as references or control factors and therewith be able to take into account dough-related deviations as well as plant-related deviations and/or properties for producing a baked end product, such as bread, that has pre-defined characteristics and properties.

SOLUTION

With the intention of solving one or more of the aforesaid technical problems the present invention takes as its starting point a dough forming method and a dough mixing arrangement in which a number of ingredients, such as flour, water and other recipe-related ingredients are mixed to an homogenous mixture in a dough mixer which is adapted to produce a pre-selected end product while evaluating the rheological properties of the dough, such as its stretch strength or toughness and/or its elasticity.

According to the invention, the dough mixer is caused to continue to work the dough mixture from at least one reference time point at which the rheological properties of the dough in the mixer exhibit a significant change, this further working of the dough being continued for a predetermined time period which is terminated at a critical time point at which the dough forming process shall cease.

According to preferred embodiments that lie within the scope of the present invention, said time point is chosen when a loose mixture of said ingredients transforms to a first dough structure.

A first reference point can be chosen when the mixture of ingredients transforms to a dough structure.

This reference time point may alternatively be chosen when the dough being formed has transformed to a second dough structure.

A second reference time point can be chosen when the developed dough formation exhibits a significant change in its rheological properties, this reference time point occurring

slightly before a time point at which maximum rheological properties exist.

It is also proposed that the mixing process is terminated at a critical time point that occurs prior to a potential time point at which such a process shall exhibit maximum rheological properties, and that said critical time point for terminating the dough forming process is chosen in accordance with predetermined factors that are governed at least by the properties of the flour used and/or requirements placed on the end product and/or on plant-related factors.

The invention is also based on the use of a measurement magnitude, such as variation(s) in the current curve to the motor driving the mixer, to represent the instantaneous rheological properties of the dough mixture.

According to further embodiments of the invention:

a) a predetermined shortest time period in the dough mixing process is chosen from a first reference time point at which a mixture of ingredients transforms to a dough formation;

b) this time period is terminated at a time point which is slightly earlier than a critical time point, and the dough forming process is stopped at said critical time point; and

c) said critical time point is selected when a following, selected significant change occurs in the rheological properties or at a later chosen time period.

According to embodiments that lie within the scope of the inventive concept, said time point under -a- shall be selected as a first reference time point, and that this reference time

point is established when a selected and significant change in the rheological properties occurs.

The value of this predetermined period will conveniently be chosen empirically.

The reference time point under -a- and the significant change in the rheological properties under -c- shall be evaluated via mathematical signal processing of the variation(s) in a measured current curve.

It is also proposed that the reference time point under -a- is chosen when an initial homogenous ingredients mixture transforms to a dough formation or dough structure and no longer clings to the walls of the mixing vessel.

It is also proposed that the critical time point under -c- is chosen when a dough formation suddenly exhibits significant changes and/or increasing rheological properties during the dough forming process, or alternatively at a later time.

It is also proposed that the variation in the current curve is divided time-wise into a number of shorter sub-sections during which instantaneous occurring current values are subjected to mathematical signal processing.

Signal processing of these short sub-sections may be effected in accordance with the varians theorem or some other statistical signal processing process.

It is also proposed that a first sub-section of short duration selected for signal processing is partially overlapped by a following sub-section chosen for signal processing.

It is particularly proposed that the reference time point relating to the first dough structure shall be capable of being corrected via a chosen, first correction factor.

According to another embodiment, the reference time point relating to the second dough structure can also be corrected via a chosen, second correction factor, where said correction factor may primarily be dependent on the subsequent treatment of the dough formation within the baking plant.

ADVANTAGES

Those advantages primarily associated with an inventive method and an inventive dough mixing arrangement reside in the creation of provisions which enable the structure of the end product to be controlled towards maximum properties, primarily by mixing recipe-related ingredients in a dough mixer to a chosen critical time point at which said rheological properties are slightly beneath and time-wise before the maximum rheological properties of the end product.

The invention provides particularly simple measures of relatively high precision and essentially regardless of immediate temperature, the sensitivity of the flour, the structure of the surroundings, and also of the ingredients, so as to evaluate the critical time point at which the dough forming process shall be stopped, by evaluating and utilizing one or more reference time points each relating to significant changes in the rheological properties of the mixture/dough formation.

The primary characteristic features of an inventive method for mixing a number of ingredients, such as flour, water and other ingredients, in a dough mixer such as to produce a pre-

determined end product are set forth in the characterising clause of the following Claim 1, while the characteristic features of a dough mixing arrangement adapted to this end are set forth in the characterising clause of Claim 18.

BRIEF DESCRIPTION OF THE DRAWINGS

A method significant to the present invention and a dough mixing arrangement adapted for carrying out the method and including a control unit having features associated with the invention will now be described in more detail with reference to the accompanying drawings, in which

Figure 1 is a greatly simplified illustration of a dough mixing arrangement in which the dough mixer is driven by an electric motor, and where load-related variations in the current curve are evaluated in accordance with instructions given in accordance with the invention;

Figure 2 shows graphs related to mean values over time-related current consumption of a dough mixer used in a baking process, said graphs being applicable to two different recipes that stipulate two different flour qualities;

Figure 3 is a block diagram which illustrates signal processing of the current curve to the electric motor driving the dough mixer;

Figure 4 is a mathematically statistical graph relating to a current curve which corresponds to the graph for the upper current curve in Figure 2 and which has

been signal processed in accordance with Figure 3; and

Figure 5 is a block diagram illustrating part of a control unit constructed in accordance with the principles of the invention, so as to enable the dough forming process to be terminated at a chosen critical time point with the aid of one or more evaluated reference time points.

DETAILED DESCRIPTION OF EMBODIMENTS AT PRESENT PREFERRED

Because the method significant of the invention has already been described above, the reader is referred for a closer understanding of the particular features of the method primarily to this description, although the method will be explained in more detail hereinafter with reference to a control unit forming part of the dough mixing arrangement.

Accordingly, Figure 1 illustrates schematically a dough mixing arrangement 1 in which a dough mixer 2 mixes recipe-related ingredients, such as flour, water and other ingredients, to form an homogenous dough formation intended for use in producing a pre-selected end product in a baking process in a known baking and product packaging plant.

The dough mixing arrangement 1 comprises a dough mixer 2, an electric motor 3, dough mixing devices, such as spirals, wings 2a or the like disposed in the mixer 2 and driven round by said motor 3 to develop a dough structure 6, a contactor 3a, an electric circuit 4 which functions to evaluate variations in the current curve representative of the current applied to the electric motor 3, and a control circuit 5 intended for evaluating, in accordance with given criteria, a selected, a critical time point -tc- at which the dough mixing

process shall be terminated in response to a signal delivered on a signal conductor 51b.

The dough kneading wings 2a are thus driven round by an electric motor 3 and the variation in the current consumption of the motor 3 is evaluated in a circuitry 4.

The following description takes its starting point from the fact that variations in the current curve deriving from the current supply on conductor 3', according to Figure 3, are representative of the rheological properties of the dough structure 6. The unit or circuitry 4 that evaluates current curve variations is connected to computer equipment which functions as a control circuit 5, relevant blocks or corresponding software of which are shown in the block diagram of Figure 5.

The present invention also assumes that the ingredients (normally all ingredients) dictated by the recipe are introduced initially into the mixer 2 and mixed homogeneously in an introductory mixing phase designated -a- in Figure 2.

This introductory phase may concern liquid ingredients such as water, milk or other ingredients, and one or more dry ingredients, such as flour, salt, sugar, etc.

This homogenising mixing process creates conditions that cause the ingredient mixture to form a dough at time point -ts-. Because this time point -ts- is important in understanding the present invention, it is referred to hereinafter as a first reference time point -ts- at which it is assumed that the mixture 6 exhibits a first dough structure.

The dough 6 is then worked during the remainder of the dough forming process during changes in the rheological properties of the dough structure, significant increases in said proper-

ties, these significantly increasing properties being important with respect to understanding the present invention.

Depending on the recipe, the aforesaid curve shape can be assumed to present a plurality of significantly changed, preferably increasing, rheological properties that can be used to evaluate a plurality of reference points.

The description of the invention will be simplified inasmuch that a significant increasing change in the rheological properties takes place at time point -tb-.

Because this time point -tb- is important in acquiring an understanding of the present invention, it is referred to as a second reference time point -tb- at which it is assumed that the dough 6 has a second structure.

The dough forming process shall be terminated at this time point -tb-, or as more usual at a time point located in a chosen time period following said time point and designated -tc-.

Reference is made to the Swedish Patent Application mentioned in the introduction, for a closer understanding of the evaluations upon which the choice of the critical time point -tc- can be based.

Maximum rheological properties occur at a time point -td-, whereas the dough will be so flat as to be torn to shreds at time point -te-. Since these time points have no bearing on the understanding of the present invention, they have only been mentioned by way of clarification.

Figure 2 illustrates two graphs relating to the time-wise, mean-value-forming changes in the current consumption of a dough mixer 2 for two different flour sorts mixed, for in-

stance, with water, milk and other recipe-related ingredients, and included in a baking process.

It will be seen from Figure 2 that, in principle, the current consumption on conductor 3' initially increases with time essentially equally for different flour qualities, although the difference in consumption is more decisive at the terminating parts of the graphs.

For instance, it will be noted that in respect of a chosen flour quality -M1- and a particular recipe requiring this flour quality, the highest current value occurs at time point -td- at which the maximum rheological properties of the dough also exist.

In the case of another chosen flour quality -M2- and a particular recipe including this flour quality, the maximum current consumption occurs at a lower value and at a slightly earlier time point -td'-.

Because the principles of the present invention are the same for both graphs, which represent flour qualities -M1- and -M2-, only the flour quality and the recipe -M1- with a maximum current value at time point -td- will be described in the following description.

Also shown in Figure 2 is an enlarged curve section adjacent time point -td- from which it will be seen that the single line current curve is, in fact, an alternating curve comprised of mean current values.

The principle of the invention is based on the premise that the graph compiled from the mean values of the current curve represents the rheological properties of the dough structure 6 at each chosen time section, with sufficient accuracy for the purpose intended.

Thus, each dough mixing process can be divided into a first phase -a-, in which loose ingredients are mixed while exhibiting no rheological properties or only low rheological properties. This state or phase is terminated at time point -ts-.

At this time point -ts-, which can be readily evaluated through the medium of distinct changes in the current curve (see Figure 4), the dough forming process transfers to a second phase -b- in which there is formed a dough structure that exhibits increasing rheological properties that can be well anticipated.

At this time point -ts-, which is referred to hereinafter as the reference point or starting point, the dough formation is solid and begins to release its contact with the inner walls 2b of the mixer 2 in the form of a coherent dough structure 6.

In the case of other recipes and different mixtures, the dough may develop into a structure 6 at which the mixture relinquishes its contact with the spiral or spirals 2a.

Although formation of the dough can be seen as being a continuous process, a closer analysis of the variations in the current curve will show that otherwise is the case.

In order to facilitate an understand of the present invention, it is assumed that a dough forming state or phase can be considered terminated at a time point -tb-. This time point -tb- is important in respect of certain applications, since the rheological properties of the dough are changed significantly at this time point to a value which is twice that of an earlier occurring peak value, as will be seen from Figure 4.

In respect of other recipes, this time point -tb- will be less pronounced, as a result of smaller variations.

This second time point -tb- (which will occur midway during the dough forming process) can serve as a further reference point, a second reference time point, at which the dough exhibits a second structure.

Figure 2 also shows a later occurring time point, referenced -tc-, which signifies a critical time point at which dough formation in the mixer 2 shall be stopped so that the rheological properties of the dough at this time point will be adapted with respect to subsequent process treatment and plant influences, so as to provide an end product, bread, that has maximised or at least compromised maximised properties.

In exceptional cases, this time point -tc- can be chosen to occur simultaneously with, to or slightly previous, the time point -tb-, although the following plant will require the time point -tc- to occur in an adapted period of time after the time point -tb-.

At time point -tb-, which can be readily evaluated by marked changes in the current curve, the dough mixing process proceeds to a third phase -c-, in which the rheological properties of the dough are uniform and increase slightly to time point -td- (see Figure 4), and thereafter decrease towards time point -te-.

Current consumption in this third phase -c- thus both increases slightly and decreases slightly in time.

When the current consumption during phase -c- is at a maximum, at time point -td-, the rheological properties of the dough, such as toughness, springiness and/or elasticity, is

also at a maximum and if the mixer 2 is allowed to run beyond said time point -td-, the dough structure will break down, e.g. become flat, and result in an end product of much poorer quality than otherwise.

The influence from this phase -c- is not taken into account in the present document, since treatment of the dough in the mixer 6 beyond time point -tc- is considered unsuitable.

Experience has shown that in each known baking process an attempt to stop the dough forming process should be made at time point -td- or somewhat earlier.

It is proposed in accordance with the present invention that a chosen recipe for a desired end product is mixed in the dough mixer 2 associated with the baking process and that it shall be possible to terminate the course followed by said process at a time point -tb- or preferably at a time point -tc-, occurring before the potential time point -td- at which such a dough mixture 6 would otherwise exhibit maximum rheological properties, in other words have maximum viscosity.

The invention is based on the ability to establish via a control circuit 5 at least one first time point -ts-, a time point serving as a first reference time point, and preferably a number of following reference time points, simplified here as a second time point -tb-, a second time point serving as a second reference time point, and, when necessary, a third time point -tc- established by calculations and other deliberations, i.e. a critical time point at which the dough forming process shall be terminated.

The time point -tc- is thus the time point at which the dough forming process is terminated, in compliance with predetermined factors described hereinafter.

Thus, the present invention is based on the realisation that the course taken by certain particular events in the mixer during the dough forming and dough mixing process shall be evaluated and said critical time point -tc- established in the control circuit 5 with the aid of these evaluations so as to terminate the dough mixing process at time point -tc-.

In order for the invention to be successful, it requires an unequivocally determined time point that can be used as a reference time point for the remainder of the dough mixing process. To this end, there is primarily evaluated the time point -ts- at which an homogenous, loose mixture of ingredients transforms to an initial dough forming phase.

The easiest way to evaluate time point -ts- is to detect variations in the current curve and to process these variations mathematically and statistically.

The time -ts- is assumed to appear between the phase -a-, when the current curve is generally constant and rises slightly with small variations of instantaneous values, and the phase -b-, where the current curve rises slightly with increasing variations of instantaneous values.

The time period covering phase -a- thus varies within wide limits without consequently needing to influence deleteriously the time point -tc- at which the dough forming process shall be terminated.

It lies within the scope of the invention to select from an established time value -ts- a time period over which the dough 6 can be formed up to the time value -tc-, particularly when the time value -tb- is not evaluated.

Between a plurality of individual ingredients mixtures, with the same weight and choice of ingredients, it is possible

that the time value -ts- will be shifted or displaced for one mixture in relation to the others.

Such a shift in the time point -ts- can be taken as evidence that the recipe-related ingredients are incorrect, thus influencing the significant changes in the rheological properties on the one hand, and/or can be taken as evidence of changes in the properties of the recipe-associated ingredients on the other hand. Consequently, an evaluated time shift can serve as a correction factor for the time point -ts- and/or the critical time point -tc-, particularly in the case of small deviations.

According to one embodiment of the invention, it is proposed that there is chosen from said time point -ts- at which the loose mixture transforms to a dough structure a predetermined time period -dt- during which the dough can be treated in the mixer 6 without transforming into said second dough structure at the significant changes of the rheological properties at time point -tb-.

This time period -dt- can be readily evaluated and is well documented.

According to the invention, there is chosen a time period -dt- that is slightly shorter than the actual time period in which dough is formed during said phase -b-.

According to the invention, this time period -dt- is adapted to end shortly before the reference time point -tb-, so as to enable the control unit 5 to calculate and evaluate the critical time point -tc- and to terminate the dough forming process at said time point -tc-.

By this choice of time period -dt-, it is possible to avoid detection of those current variations within said time period

-dt- that could otherwise be interpreted as an erroneous transition between phase -b- and phase -c-.

Thus, during the time period -dt-, it is possible to fully block or at least partially block the influence deriving from variations in the current values, for signal processing and controlling of the control unit 5.

The measurement values obtained in respect of time point -tb- may conveniently be used for statistical evaluation of the graph shown in Figure 4.

The value of the predetermined time period -dt- may conveniently be chosen empirically. No precise, qualified evaluation is required to this end, but simply that the time period -dt- is terminated before the time point -tb-.

The time point -tb- and said significant change in the rheological properties at time point -ts- are evaluated via special signal processing of the variation in the current curve.

The special signal processing of the variation of the current curve may conveniently take into account instantaneous values of the current peaks, the slope of the curve shape and/or the number of current peaks within a sub-section.

The statistical signal process applied may conveniently be in accordance with the varians theorem, as described in more detail in the publication mentioned in the introduction.

It is also possible in accordance with the invention to divide the time-wise variation of the current curve into a number of time-related sub-sections during which signal processing of occurring instantaneous current values is effected separate from other sub-sections.

According to one particular embodiment of the invention, a first sub-section intended for signal processing is caused to be overlapped partially by a following sub-section also intended for signal processing.

Figure 3 illustrates signal processing of the current curve to the electric motor 3 driving the mixer 2.

The electric circuitry 4 includes a first circuit 4a which is adapted to detect current variations on the conductor 3' and, when necessary, divide the current values into a number of mutually sequential time slots 31, 32, 33 (illustrated in Figure 3).

The electric circuitry 4 also includes a second circuit 4b which is adapted to perform two functions, these functions being to allow signal processing to be effected in accordance with the varians theorem and to allow a first sub-section, or time slot, chosen for signal processing to be overlapped by a following sub-section also selected for signal processing.

Also shown in Figure 3 are time slots 31' and 32' which are orientated between the time slots 31, 32 and 32, 33 respectively so as to create conditions which prevent information important to the evaluating process from falling between the time slots.

Figure 4 is a graph showing a signal processed current curve, illustrated in Figure 2, from which it will be seen that the curve shape is such as to enable the time positions -ts- and -tb- to be evaluated with a satisfactory degree of precision, with the aid of the pronounced peak values.

When choosing a different signal processing operation, the time positions -ts- and -tb- can be caused to have minimum values.

Figure 5 is a block schematic, or program form, which includes part of a control unit 5 by means of which the dough mixing process can be terminated at a chosen critical time point -tc-.

To this end, there arrive on conductor 34 from the circuitry 4 processed signals whose structure corresponds to the graph in Figure 4.

The process signals on the conductor 34 are detected through the medium of a circuit 51 and a start signal applied to said circuit on the conductor 51a.

A start signal is sent to a timing circuit 52 on a conductor 52a, when a significant peak value occurs in the signal structure.

This timing circuit 52 can now send an activating signal on the conductor 51b so as to drive the mixer 2 for a predetermined time period -dt'- via the motor 3, said time period being adapted to stop the mixer 2 at said critical time point -tc-.

On the other hand, the timing circuit 52 may be adapted to block the circuit during an active time period, via a conductor 52b, so that no evaluation of the signals takes place on conductor 34.

The circuitry 52 thus includes a circuit which produces a blocking signal during the time period -dt-.

The signal structure may, of course, also be evaluated during said circuit blocking time so as to enable a signal processing that is dependent on earlier occurring signal structures to be performed after said time period -dt-.

The period of the time period -dt- can be adjusted by means of a signal on a conductor 52c.

Such an adjustment can be made empirically or through the medium of a time calculating circuit (not shown) where time values are calculated on the basis of recipe-related magnitudes, plant-related magnitudes, etc.

The circuit 51 is against switched-on at the end of the time period -dt-, for evaluation of variations in the current curve (according to Figure 4) via a signal on a conductor 52d.

Upon the occurrence of a significant peak value in the signal structure, the first occurring peak value at time point -tb- after the end of the time period -dt-, a signal can be sent on the conductor 51b to the contact 3a, which breaks the current supply to the mixer 2 and the dough structure is now the structure desired for further processing in the following baking process with respect to obtaining a uniform and high quality end product.

In the aforedescribed application, it can be assumed that the dough structure and the subsequent baking process will together provide an end product of high and even quality, where the reference value -tb- is represented by the critical time point -tc-.

A more normal procedure is to work the dough in the mixer 2 over a further time period (-tc-) - (-tb-) in response to a signal on the conductor 51c.

This further time period is evaluated empirically or calculated and will depend, *inter alia*, on the recipe, the following baking process, factors relating to plant machines, etc.

Changes in the position of the time point -ts- can also be compensated for by adding the ingredients during time periods -dt-.

Although the principles on which the invention is based have been described above with reference to flour-based ingredients, it will be understood that the invention can be applied also in the production of foodstuffs in the form of pasta, meatballs, etc., for instance.

Neither does the invention required access to ingredients-related reference data and graphs, but can provide a highly qualitative and uniform end product solely by reading the graphs in Figures 2 and 4 and choosing the critical time position -tc- in accordance with the guidelines given above.

A correction factor, negative or positive, can be applied to the reference time point -ts- via a conductor 51e, and primarily a positive correction factor can be applied either to the time period -dt- or to the critical time point -tc- via a conductor 51f.

The correction factor on the conductor 51e is adapted to steer the reference time point -ts- towards a normal value, whereas the correction factor on the conductor 51f is adapted to endeavour to choose the critical time point -tc- on the basis of the correction on conductor 51e and other parameters, so that the dough 6 will have the properties required to produce a chosen end product that has the aforesaid properties subsequent to the dough having passed through subsequent treatment stages.

It will be obvious to technicians conversant with this field that it is necessary to provide the control unit containing the circuitry 51 with a first means 61 that has a circuit ar-

rangement for sensing/reading the curve form in Figure 4 and to transmit a signal on the conductor 61a at the inflection point at time -ts-.

A second means 62 shall calculate or store a value of the time period -dt-, this value being outputted via a conductor 62a.

A third means 63 is adapted to calculate the time period (tb) - (tc) and send a signal on a conductor 63a.

A fourth means 64 is adapted to allocate the circuit 51 an empirical value for the time period -dt-, via the conductor 64a.

A fifth means 65, adapted to detect current variations on the conductor 3' and, when necessary, divide the current values into mutually sequential time slots, can be likened to the circuit 4a in Figure 3.

A sixth means 66, adapted to allow signal processing to be effected in accordance with the varians theorem, and a seventh means 67, adapted to allow a first sub-section chosen for signal processing to be overlapped by a following sub-section also selected for signal processing, can be likened to the circuit 4b in Figure 3.

It will be understood that the invention is not restricted to the aforedescribed and illustrated exemplifying embodiment thereof, and that modifications can be made within the scope of the following Claims.

CLAIMS

1. A method of mixing together a number of recipe-related ingredients, such as flour, water and other ingredients, in a dough mixer to form a dough mixture intended for producing a pre-selected end product while evaluating the rheological properties of the dough mixture, wherein the dough mixing process is terminated at a critical time point which occurs prior to a potential time point at which said dough mixture would exhibit maximum rheological properties, and wherein the instantaneous rheological properties of the dough mixture are represented by the change and/or variation in the current curve or some other measurement magnitude, **characterised** by causing the dough mixer to mix the dough over a predetermined time period towards said critical time point at which the dough mixing process shall cease, said predetermined time period starting from the reference time point at which the rheological properties of the dough mixture exhibit a significant change.

2. A method according to Claim 1, **characterised** by selecting said reference time point when a mixture of ingredients exhibits a first dough structure.

3. A method according to Claim 2, **characterised** by selecting said first reference time point when the mixture of ingredients transforms to a dough structure.

4. A method according to Claim 1, **characterised** by selecting said reference time point when the dough formation exhibits a second structure.

5. A method according to Claim 4, **characterised** by choosing as said second dough structure a structure in which the rheological properties of the dough formation begin to exhibit a significant change at a time point that occurs some-

what earlier than a time point at which maximum rheological properties exist.

6. A method according to Claim 1, **characterised** by

a) selecting from the time at which the mixture is caused to transform to a dough formation by said mixer a predetermined time period during which the mixer, is at least activated;

b) terminating said time period at a time point that occurs somewhat earlier than said critical time point, so as to end the dough mixing process at said critical time point; and

c) selecting said critical time point when a following selected and significant change of the rheological properties takes place or in a selected later time period.

7. A method according to Claim 6, **characterised** by selecting said time point under -a- on the occurrence of a selective and significant change in said rheological properties.

8. A method according to Claim 6, **characterised** by selecting the value of said predetermined time period empirically.

9. A method according to Claim 6, **characterised** by signal processing the variation of a current curve such as to evaluate the time point under -a- and the significant change in the rheological properties of the dough under -c-.

10. A method according to Claim 6, **characterised** by selecting said time point under -a- when an initial homogenous mixture of ingredients transforms into a dough formation that has release its contact with the walls of the mixer.

11. A method according to Claim 6, **characterised** by selecting said time point under -c- when the rheological properties of a dough formation suddenly change during the dough mixing process, such as to increase significantly.

12. A method according to Claim 1, **characterised** by dividing the variation in said current curve into a number of sub-sections during which signal processing of occurring instantaneous current values takes place.

13. A method according to Claim 12, **characterised** by effected said signal processing in accordance with the variants theorem.

14. A method according to Claim 12, **characterised** by partially overlapping a first sub-section chosen for signal processing with a subsequent sub-section chosen for signal processing.

15. A method according to Claim 1 or 2, **characterised** by correcting a first reference time point with a chosen first correction factor.

16. A method according to Claim 1, 2 or 4, **characterised** by correcting a second reference time point with a chosen second correction factor.

17. A method according to Claim 16, **characterised** in that the correction factor is dependent on the treatment of the dough formation following said dough mixer.

18. A dough mixing arrangement for mixing together recipe-related ingredients, such as flour, water and other ingredients, to form a dough mixture in the preparation of a pre-selected end product in a dough mixer while evaluating the rheological properties of said mixture, wherewith a dough

mixing process shall be terminated at a critical time point that occurs earlier than a potential time point at which the dough mixture exhibits maximum rheological properties, and wherewith the configuration and/or the variation or some corresponding measurement magnitude of the current curve is allowed to represent the instantaneous rheological properties of the dough mixture, **characterised** in that the dough mixer is adapted to form a dough structure through the medium of a control circuit over a predetermined time period towards the critical time point at which the dough forming process shall cease, said predetermined time period being started at a selected reference time point at which the rheological properties of the dough mixture exhibit a significant change.

19. An arrangement according to Claim 18, **characterised** by control units that can evaluate said reference time point when a mixture of ingredients exhibits a first dough structure.

20. An arrangement according to Claim 19, **characterised** in that the control unit functions to evaluate said first dough structure when said mixture of ingredients transforms to a dough structure.

21. An arrangement according to Claim 18, **characterised** in that the control unit functions to evaluate said reference time point when a dough formation exhibits a second dough structure.

22. An arrangement according to Claim 21, **characterised** in that the control unit functions to evaluate said second dough structure when the rheological properties of said developed dough formation change significantly, at a time point which occurs somewhat earlier than the time point at which the dough has maximum rheological properties.

23. An arrangement according to Claim 18, **characterised** in that

a) the control unit has associated first means which function to evaluate a time point at which the mixture of ingredients transforms to a dough formation; in that the control unit has associated second means which function to select a predetermined time period within which the dough mixer is at least activated;

b) in that said time period is adapted to cease at a time point somewhat earlier than the critical time point, so as to terminate the dough mixing process at said critical time point; and

c) in that the control unit has associated third means which function to evaluate said critical time point in response to a selected and significant change in said rheological properties or in a later, selected time period.

24. An arrangement according to Claim 23, **characterised** in that said first means establishes said time point on the basis of a chosen, significant change in said rheological properties.

25. An arrangement according to Claim 23, **characterised** in that the control unit has fourth means which functions to establish the value of said predetermined time period empirically or in some similar manner.

26. An arrangement according to Claim 23, **characterised** in that said first means and said third means are adapted to evaluate requisite time points via signal processing of the variations in the current curve.

27. An arrangement according to Claim 23, **characterised** in that said first means is adapted to select a time point at which an initially homogenous mixture of ingredients transforms to a dough structure.

28. An arrangement according to Claim 23, **characterised** in that said third means is adapted to establish when a dough formation suddenly exhibits changed rheological properties, such as significantly increasing rheological properties, during the dough mixing process.

29. An arrangement according to Claim 23, **characterised** in that said fifth means is adapted to enable variations in said current curve to be divided into a number of sub-sections in which instantaneously occurring current values are signal processed.

30. An arrangement according to Claim 29, **characterised** by a sixth means which is adapted to allow signal processing to be effected in accordance with the varians theorem.

31. An arrangement according to Claim 29, **characterised** by a seventh means which is adapted to allow a first sub-section chosen for signal processing to be overlapped by a following sub-section also selected for signal processing.

32. An arrangement according to Claim 19, **characterised** in that the control unit functions to correct a chosen time point for a first dough structure through the medium of a chosen correction factor.

33. An arrangement according to Claim 19 or 21, **characterised** in that the control unit functions to correct a chosen time point for a second dough structure with the aid of a chosen second correction factor.

34. An arrangement according to Claim 33, **characterised** in that the correction factor is adapted by the control unit or the like in accordance with the treatment of the dough formation after the dough mixer.

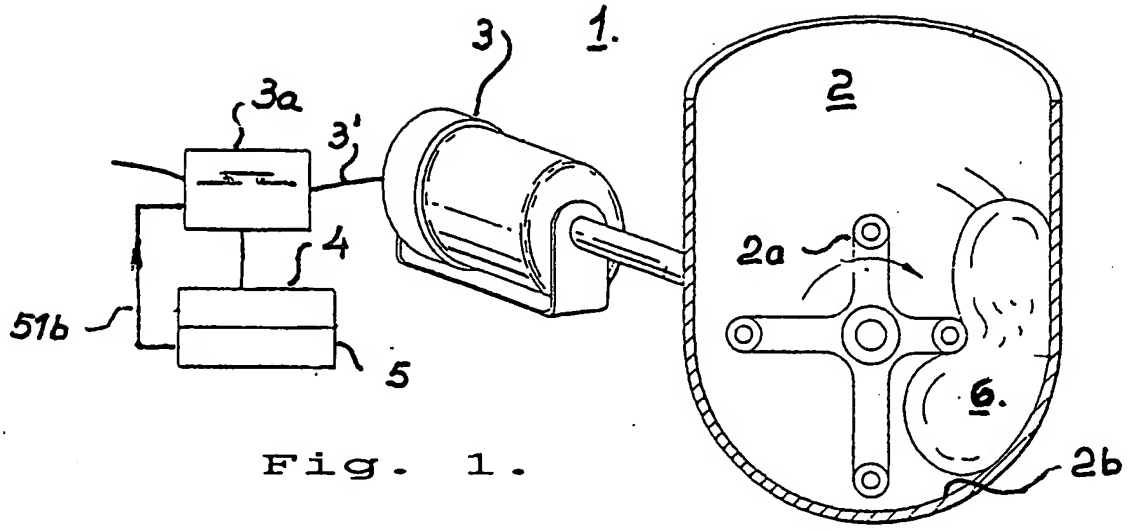


Fig. 1.

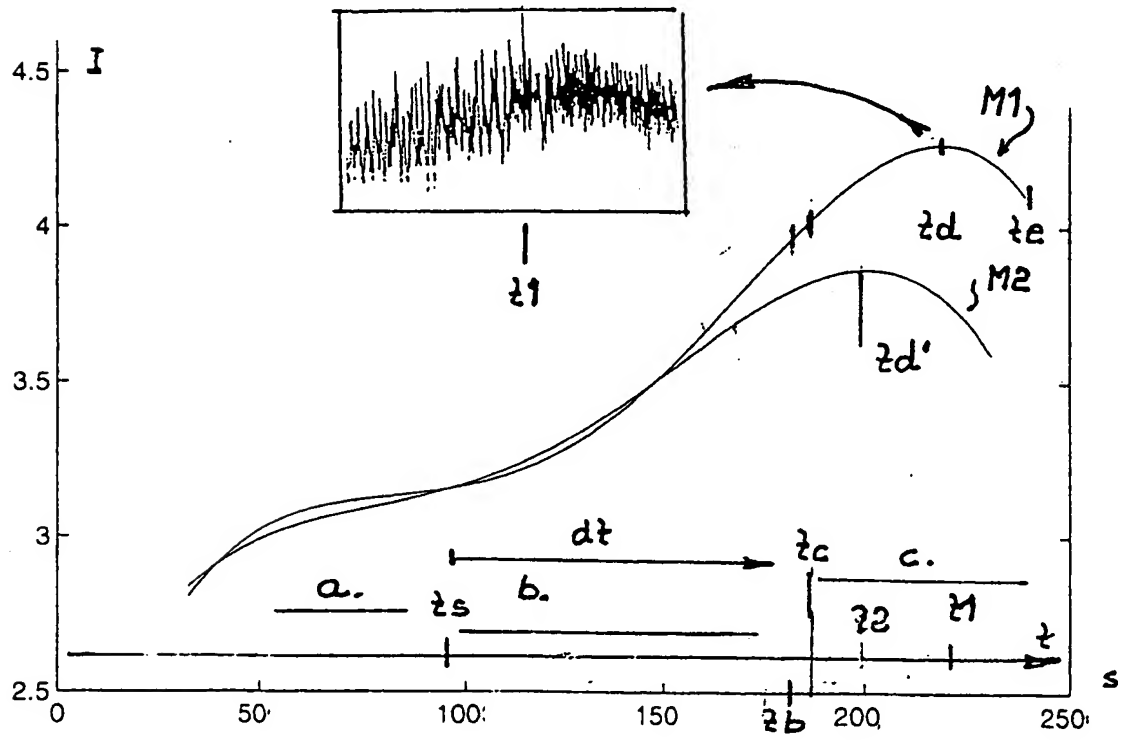


Fig. 2.

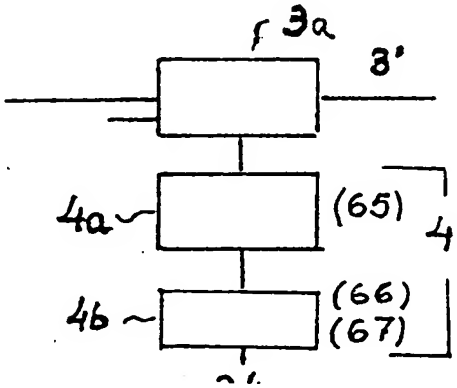
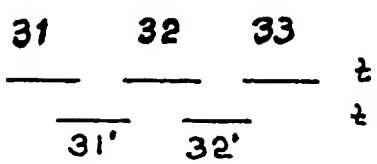


Fig. 3.



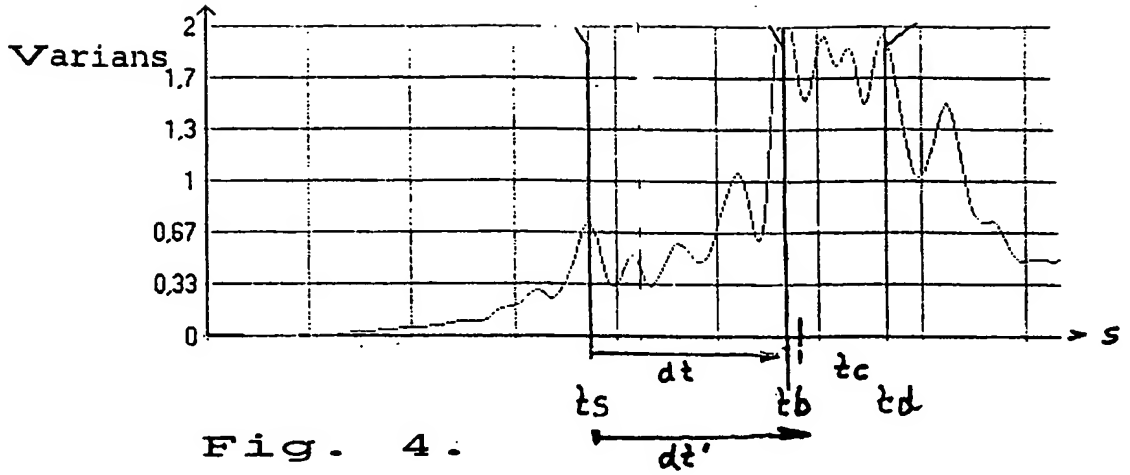

Varians
2
1,7
1,3
1
0,67
0,33
0
s
dt
ts
tb
tc
td
dt'

Fig. 4.

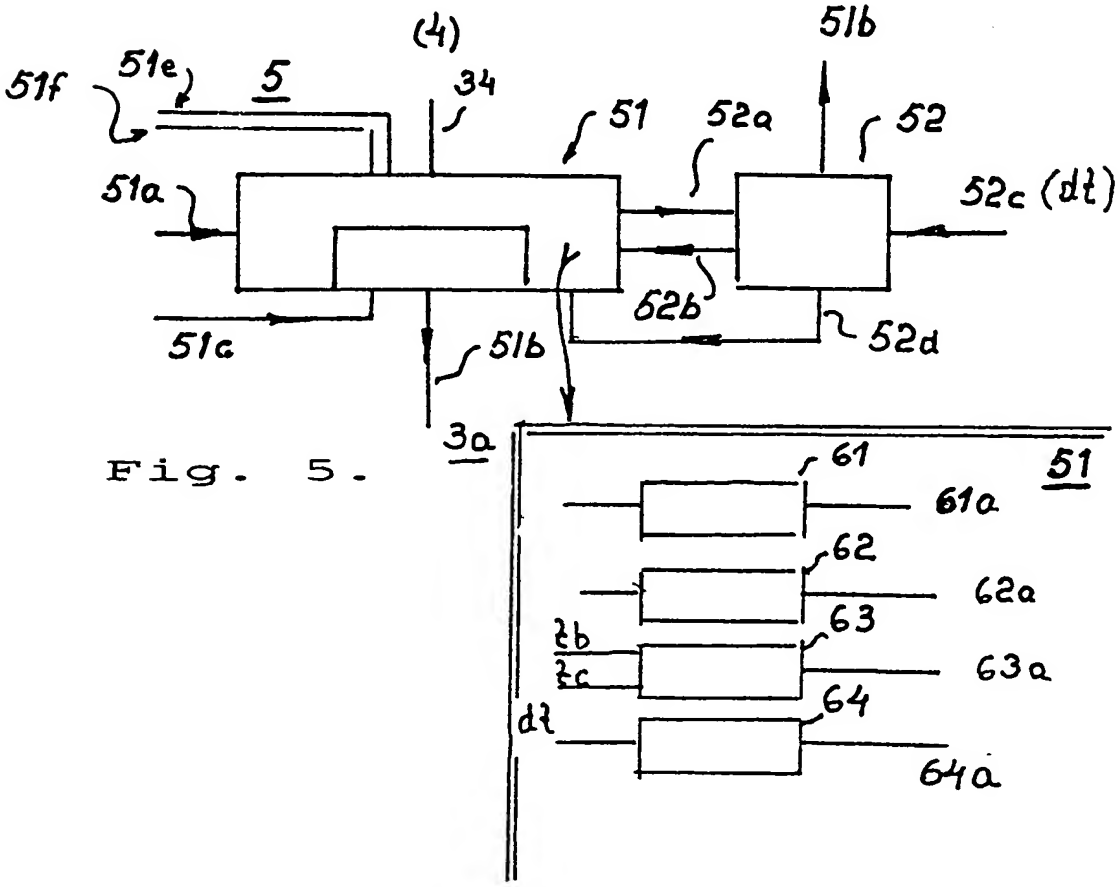

(4)
51b
51f
51e
5
34
51
52a
52
51a
52c (dt)
52b
52d
51c
51b
3a
51
61
61a
62
62a
63
tb
tc
63a
dt
64
64a

Fig. 5.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/00880

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A21D 8/02, A23C 1/00, G01N 33/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A21D, A23C, G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0428241 A1 (SYSTEM SOUGOU KAIHATSU CO. LTD.), 22 May 1991 (22.05.91) --	1-34
P,A	WO 9920113 A1 (CEREALIA UTVECKLING AB), 29 April 1999 (29.04.99) --	1-34
A	US 5472273 A (EDDIE R. FOWLER ET AL), 5 December 1995 (05.12.95) -- --------	1-34

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 Sept 1999	01 -10- 1999
Name and mailing address of the ISA/	Authorized officer